UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 155
Seattle, WA 98101-3123

OFFICE OF
WATER AND
WATERSHEDS

MEMORANDUM **Draft (October 2020)**

SUBJECT: Cormix Modeling for PotlatchDeltic St. Maries Outfall 001

FROM: Brian Nickel, Environmental Engineer
NPDES Permits Section, Water Division, EPA Region 10

TO: The File (NPDES Permit #ID0000019)

1 Introduction

Version 11.0 GTD of the CORMIX Mixing Zone Expert System (CORMIX) was used to evaluate the mixing properties of the discharge from the PotlatchDeltic St. Maries Complex for the purpose of determining regulatory mixing zones for toxic pollutants.

2 Description of Receiving Waters and Discharge

2.1 Receiving Water

Effluent from the PotlatchDeltic St. Maries complex is discharged to the St. Joe River at 47.329722 north latitude and 116.590278 west longitude.

2.2 Outfall 001

The effluent is released through outfall 001 from an open pipe. Measurements were obtained from Jacob Odekirk of PotlatchDeltic via e-mail.

3 The Coeur d'Alene Tribe's Mixing Zone Policy

Several provisions of the Coeur d'Alene Tribe's mixing zone policy are potentially applicable to PotlatchDeltic's discharge of toxic pollutants, including:

- The allowable size, shape, and location of a mixing zone shall be established in certifications under Section 401 of the CWA, or orders, as appropriate. In determining the location, surface area, and volume of a mixing zone, the Department or EPA may use appropriate mixing zone guidelines (such as EPA 505/2-90-001)[1] to assess the biological, physical, and chemical character of receiving waters, and effluent, and the most appropriate placement of the outfall, to protect instream water quality, public health, and other designated uses.
- No mixing zone shall be granted unless the supporting information clearly indicates the mixing zone would not have a reasonable potential to cause a loss of or impair recovery of aquatic life, wildlife, or sensitive or important habitat; create a barrier to migration of species; or substantially interfere with the existing or designated uses of the water body as a whole; result in damage to the ecosystem; or adversely affect threatened and endangered species or public health as determined by the Department.

[1] This is the Technical Support Document for Water Quality-based Toxics Control or TSD. https://www3.epa.gov/npdes/pubs/owm0264.pdf

- No Mixing zone shall be granted unless the supporting information clearly indicates that it would not cause lethality to organisms passing through the mixing zone.
- Mixing zones shall be as small as feasible, and shall minimize the adverse effects on the indigenous biological community, especially when species are present that warrant special protection for their cultural significance, economic importance, ecological uniqueness, or for other similar reasons as determined by the Department.
- Mixing zone specifications and water quality-based effluent limits shall be based on the following critical design flows:
    - Chronic criteria: the 7Q10 flow
    - Acute criteria: 1Q10 flow or at the point of discharge
    - Human health criteria - carcinogens: harmonic mean flow
    - Human health criteria - non-carcinogens: the 30Q5 flow
    - Ammonia – 30B3

4 Mass Balance

Initially, EPA calculated dilution factors based on a mass balance, pairing the year-round maximum reported effluent flow of 1.1 mgd (1.7 CFS) with the year-round critical low flows of the St. Joe River, and using 25% of the river flow for mixing. Results of the mass balance are listed in Table 1.

Table 1: Mixing Zones Based on Mass Balance

Criteria Type	Critical Low Flow (cfs)	Mixing Zone (% of Critical Low Flow)	Dilution Factor	% Effluent
Acute Aquatic Life (1Q10)	125	25%	19.4	5.15%
Chronic Aquatic Life (except ammonia) (7Q10)	258	25%	38.9	2.57%
Chronic Aquatic Life (ammonia) (30B3)	408	25%	60.9	1.64%
Human Health Noncarcinogen (30Q5)	363	25%	54.3	1.84%
Human Health Carcinogen	1076	25%	159.1	0.629%

5 Cormix Modeling

The EPA used the Cormix model (version 11.0 GTD) to evaluate the mixing properties of the discharge and determine whether the preliminary mixing zones based on a mass balance (Table 1) would comply with the Tribe's mixing zone policy. Cormix is a comprehensive software system for the analysis, prediction, and design of outfall mixing zones resulting from discharge of aqueous pollutants into diverse water bodies.

5.1 Model Inputs

The Cormix model inputs and their bases are described below.

5.1.1 Effluent Tab

The effluent flow rate was set at 1.1 million gallons per day (mgd) for October - May runs and 0.477 mgd for June - September runs. These are the maximum monthly effluent flow rates reported by the facility for these seasons between November 1996 and January 2020.

The effluent temperature was used to specify the effluent density. The effluent temperature was set equal to 16 °C for October - May runs; this was the maximum effluent temperature reported in October. The October temperature was used for the October - May runs because the lowest ambient velocities within the October - May season are generally observed in October. The effluent temperature was set equal to 27.9 °C for June - September runs; this was the maximum effluent temperature reported during this season.

A discharge excess concentration of 100% was specified. Thus, the edge-of-mixing-zone concentrations reported in the model results are equivalent to percent effluent. This is convenient when applying Cormix model results to multiple pollutants.

5.1.2 Ambient Tab

5.1.2.1 Ambient Width and Depth

Mr. Odekirk stated that, at the time of measurement, the depth of the river at the point of discharge was about 7.5 feet.

A river cross-section obtained from the Coeur d'Alene Tribe indicates that the average depth of the river near the point of discharge is roughly 20 - 25 feet (Figure 1).

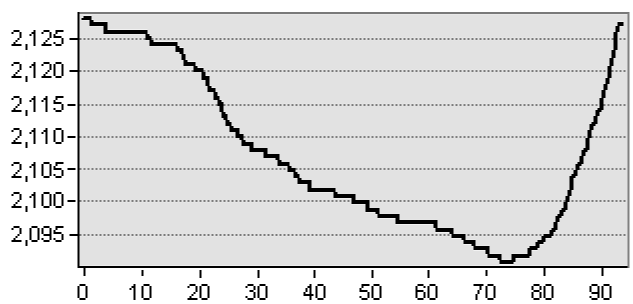

Figure 1: St. Joe River Cross Section at Outfall 001. The y-axis is elevation in feet; the x-axis is distance in meters from the south bank.

However, Cormix will only accept an "average depth" that is 30% deeper than the depth at discharge. In order to ensure that boundary interactions with the river bottom were captured in the model, the depth at discharge was specified as 7.5 feet (2.29 meters) as reported by Mr. Odekirk. The "average depth" was set to the maximum allowable value of 9.75 feet (2.97 meters).

The river width was scaled such that the total flow was equal to the 7Q10 flow rate of 258 CFS, regardless of the specified velocity. This ensures that Cormix calculates an accurate limiting or "complete mix" dilution factor. As shown in Figure 1, the actual river width at the point of discharge is roughly 95 meters (312 feet).

5.1.2.2 Ambient density

EPA characterized the ambient density using measured ambient temperatures. Since the discharge location is in a shallow portion of the river, vertical temperature stratification is not expected near the outfall location. Thus, the "uniform" ambient density option was selected.

The ambient temperature was set equal to 15.4 °C for October - May runs and 25.5 °C for June - September runs. These were the 95th percentile ambient temperatures observed at USGS station #12415075, upstream from the discharge, in October and during June - September, respectively. October temperatures were used for the October - May runs because the lowest river flows and ambient velocities within the October - May season are generally observed in October.

5.1.2.3 Ambient Velocity

Ambient velocity measurements were available from USGS at station number 12415135, "St. Joe River at Ramsdell near St. Maries, ID." Velocities associated with river flows less than the 30Q5 (Table 1) ranged from 0.01 - 0.06 ft/s.[2] Model runs were conducted for this range of velocities, at 0.01 ft/s intervals. As explained in section 4.1.2.1, the channel width was scaled such that the total flow was equal to the 7Q10 flow rate of 258 CFS, regardless of the specified velocity.

Note that the only measurement with a velocity of 0.01 ft/s corresponded to flow rate of 68.1 CFS, which is less than the 1Q10 flow rate (Table 1). However, since the discharge is in a shallow portion of the river and near the bank, the local velocity near the point of discharge could be lower than the bulk or average velocity throughout the river channel. Thus, it is reasonable to conduct model runs with ambient velocities as low as 0.01 ft/s.

5.1.2.4 Wind Speed

The wind speed was specified as 2 meters per second (4.5 miles per hour). This is the value recommended by the Cormix user manual as a conservative estimate, when field data are not available (Doneker and Jirka 2014).

5.1.2.5 Roughness

The EPA specified a Manning's "n" of 0.025 because it is the appropriate factor to use for an earthen channel with some stones and weeds, according to Table 4.3 of the Cormix user manual (Doneker and Jirka 2014).

5.1.3 Discharge Tab

The EPA selected the "CORMIX1" option because outfall 001 is an open pipe (single port).

The nearest bank is on the left, from the perspective of an observer looking downstream. Mr. Odekirk stated that the outfall is about 1.5 feet from the nearest bank.

The port height is the height of the discharge port centers above the bottom of the river. This value is 0.5 feet, based on Mr. Odekirk's measurements.

Mr. Odekirk provided the outer diameter of the discharge pipe as 14 inches. EPA estimated an inner diameter of 13.5 inches.

---

[2] https://waterdata.usgs.gov/id/nwis/measurements?site_no=12415135&agency_cd=USGS&format=html_table_expanded

Mr. Odekirk stated that the pipe is "almost vertical." This would correspond to a vertical angle "theta" of almost -90°. However, the largest negative vertical angle that Cormix will accept is -45°. Therefore, the vertical angle "theta" is specified as -45°.

The horizontal angle "sigma" is specified as 270°, which means the discharge pipe is perpendicular to the river flow and pointed toward the opposite bank.

5.1.4 Mixing Zone Tab

The "toxic effluent" option was selected.

Initially, the criterion maximum concentration (CMC or acute criterion) and criterion continuous concentration (CCC or chronic criterion) were specified to be the effluent percentages calculated from mass balances for the acute and chronic mixing zones (Table 1).

The model output then used to determine the downstream distance at which the chronic dilution factor from Table 1 was achieved. This distance was subsequently specified as the mixing zone downstream distance, "x." It is useful to specify a mixing zone size in the "mixing zone" tab, because this allows Cormix to determine if the CMC or acute dilution factor is achieved within one tenth the distance of the extent of the chronic or regulatory mixing zone.

5.2 Model Results

Model results are summarized in Table 2, below.

Table 2: Cormix Results Summary

Season	Velocity (ft/s)	Width (ft)	Distance to achieve 19.4:1 Dilution Factor (m)	Travel Time to achieve 19.4:1 Dilution Factor (minutes)	X-Distance to achieve 38.9:1 Dilution Factor (m)	Dilution Factor Meeting Criteria in TSD §4.3.3
Oct. - May	0.06	441	46.33	34	203.14	5.8
Oct. - May	0.05	529.2	67.93	70	212.28	5.46
Oct. - May	0.04	661.5	98.11	133	216.56	5.26
Oct. - May	0.03	882	108.32	194	205.12	5.1
Oct. - May	0.02	1323	38.14	109	121.75	5
Oct. - May	0.01	2646	81.75	549	95.75	**4.33**
June - Sep.	0.06	441	165.5	151	258.86	5.8
June - Sep.	0.05	529.2	161.54	178	249.21	5.34
June - Sep.	0.04	661.5	143.87	198	226.3	5.2
June - Sep.	0.03	882	96.75	180	179.8	4.85
June - Sep.	0.02	1323	31.03	90	40.41	**1.479**
June - Sep.	0.01	2646	34.42	195	54.37	2.57

5.2.1 Acute Mixing Zone or Toxic Dilution Zone

In general, acute water quality criteria or CMCs are expressed as 1-hour average concentrations not to be exceeded more than once every three years. Section 2.2.2 of the

Technical Support Document for Water Quality-based Toxics Control (TSD) states that, "In many situations, travel time through the acute mixing zone must be less than roughly 15 minutes if a 1-hour average exposure is not to exceed the acute criterion." As shown in Table 2, the travel time to achieve the acute dilution factor based on a mass balance (19.4:1) is longer than 15 minutes for all scenarios. In addition, in no case did the acute dilution factor based on a mass balance (19.4:1) meet the criteria in Section 4.3.3 of the TSD.

The dilution factors meeting the criteria in section 4.3.3 of the TSD were determined by iteratively adjusting the CMC in the "Mixing Zone" tab (which changes the corresponding dilution factor) until Cormix reported that all three criteria in Section 4.3.3 of the TSD were satisfied.

As shown in Table 2, above, the Cormix model generally predicts that acute dilution factors compliant with the criteria in section 4.3.3 of the TSD are lowest during low-velocity conditions, although the worst case June - September acute dilution factor occurs at an ambient velocity of 0.02 ft/s instead of 0.01 ft/s.

The results evaluating the criteria in Section 4.3.3 of the TSD from the Cormix "session report" file for the critical October - May scenario (an ambient velocity of 0.01 ft/s) is as follows:

```
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 23.100000  %
Corresponding dilution                   = 4.329004
The CMC was encountered at the following plume position:
  Plume location:                      x = 0.19 m
    (centerline coordinates)           y = -9.82 m
                                       z = 0 m
  Plume dimension:       half-width (bh) = 0.17 m
                          thickness (bv) = 0.17 m

 Computed distance from port opening to CMC location = 9.82 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
              Lq = 0.30 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 9.82 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
              HD = 2.29 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 Computed distance from port opening to CMC location = 9.82 m.
 CRITERION 3: This location is within one tenth the distance of the extent
              of the Regulatory Mixing Zone of 98.42 m in any
              spatial direction from the port opening.
 +++++ The Regulatory Mixing Zone TEST for the TDZ has been SATISFIED. ++++++

 The diffuser discharge velocity is equal to 0.52 m/s.
 This is below the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
```

The results of evaluating the criteria in Section 4.3.3 of the TSD from the Cormix "session report" file for the critical June - September scenario (an ambient velocity of 0.02 ft/s) is as follows:

```
*********************** TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 67.620000  %
Corresponding dilution                   = 1.478852
The CMC was encountered at the following plume position:
  Plume location:                      x = 0.05 m
    (centerline coordinates)           y = -2.32 m
                                       z = 0 m
  Plume dimension:       half-width (bh) = 0.23 m
                          thickness (bv) = 0.23 m

 Computed distance from port opening to CMC location = 2.33 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.30 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.32 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 2.29 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 Computed distance from port opening to CMC location = 2.33 m.
 CRITERION 3: This location is within one tenth the distance of the extent
             of the Regulatory Mixing Zone of 40.78 m in any
             spatial direction from the port opening.
 +++++ The Regulatory Mixing Zone TEST for the TDZ has been SATISFIED. ++++++

 The diffuser discharge velocity is equal to 0.23 m/s.
 This is below the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
```

5.2.2 Chronic or Regulatory Mixing Zone

The Coeur d'Alene Tribe's mixing zone policy does not specify a maximum allowable size for chronic mixing zones, and the TSD does not recommend specific criteria for sizing chronic mixing zones.

In all cases, the chronic dilution factor based on a mass balance is achieved within 40.4 - 250 meters downstream of the point of discharge. Because the chronic mixing zone is based the year-round 7Q10 low flow (as per the Tribe's mixing zone policy) and the year-round maximum effluent flow, uses only 25% of the river flow for mixing, and because the Cormix model predicts that this dilution factor will be achieved no more than 250 meters downstream from the point of discharge, EPA considers the chronic dilution factor from the mass balance (38.9:1) to be acceptable.

5.2.3 Results Summary and Use

Based on these results, reasonable potential and water quality-based effluent limit calculations for the PotlatchDeltic St. Maries Complex outfall 001 will use the minimum acute dilution factors that meet the criteria in Section 4.3.3 of the TSD, which are 4.33:1 from October - May and 1.48:1 from June - September (Table 2).

Dilution factors for chronic and human health criteria will be those based on the mass balance, as shown in Table 1.

6 References

Doneker, R.L. and G.H. Jirka. 2014. *CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters*. December 2007. Updated August 2014.

EPA. 1991. *Technical Support Document for Water Quality-based Toxics Control.* US Environmental Protection Agency, Office of Water, EPA/505/2-90-001. March 1991. http://www.epa.gov/npdes/pubs/owm0264.pdf